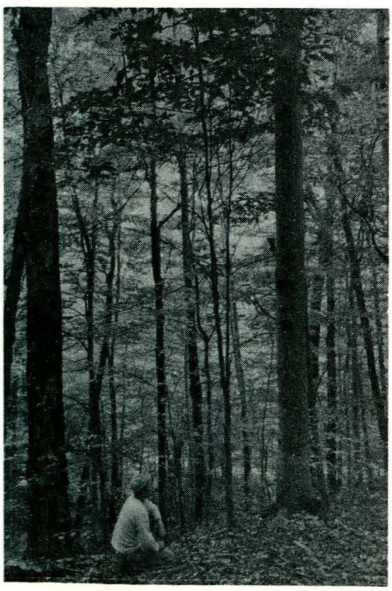
Development of

Old-Growth Northern Hardwoods

on Bartlett Experimental Forest

—a 22-Year Record

by Stanley M. Filip
David A. Marquis
William B. Leak



STATION PAPER NO. 135 • NORTHEASTERN FOREST EXPERIMENT STATION • 1960
FOREST SERVICE • U. S. DEPARTMENT OF AGRICULTURE • UPPER DARBY, PA.
RALPH W. MARQUIS, DIRECTOR

The Authors–

STANLEY M. FILIP *received his forestry training at the Pennsylvania State University, and has worked in the field of forest management for the past 15 years. His experience includes positions in industrial and farm forestry. His research work with the U. S. Forest Service began in 1946, and most of this time has been spent in management studies of northern hardwoods in Pennsylvania and New Hampshire.*

DAVID A. MARQUIS *received his Bachelor of Science degree in forestry from the Pennsylvania State University in 1955. After a 2-year tour of duty with the Army, he joined the forest-management staff of the Northeastern Forest Experiment Station's research center at Laconia, N.H., in the fall of 1957.*

WILLIAM B. LEAK *received his Bachelor's and Master's degrees in forestry from the State University of New York, College of Forestry, in 1953 and 1956. Since October 1956, he has served as a research forester in Northeastern Forest Experiment Station. He spent 1½ years in hardwood nursery and planting research at Burlington, Vt., prior to his current assignment in northern hardwood silviculture at the Laconia Research Center.*

Development of

Old-Growth Northern Hardwoods

on Bartlett Experimental Forest —a 22-Year Record

by Stanley M. Filip
David A. Marquis
William B. Leak

NORTHERN hardwood forests provide the industries of New England with their most valuable woods: yellow birch and sugar maple for veneer, paper birch for turning stock, and other hardwood species for a variety of specialty products. As a result of recent developments in hardwood pulping, these northern hardwood forests now represent a tremendous reservoir of raw material to the pulp and paper industry. To ensure a continued and balanced supply of timber for these wood-using industries, foresters must be well equipped with information on the growth and development of northern hardwoods.

The available literature on growth of northern hardwoods is concerned largely with stand behavior during the first few years after cutting. In contrast, this report describes the development of undisturbed[1] old-growth north-

[1]There has been no cutting in these stands since establishment of the plots in 1931-32, and little cutting previously since about 1900.

ern hardwoods (fig. 1) over an average period of 22 years (range of 19 to 25 years). The information is based on records from 50 permanent ¼-acre cruise plots located on the Bartlett Experimental Forest in New Hampshire--a 2,600-acre tract that is fairly typical of many hardwood forests in New England.

The plots were established in 1931 to 1932. Remeasurements were taken in 1939-40 and again in 1950-58. The two growth periods 1931-39 and 1940-58 are used as the basis for the data and discussion.

Growth & Development

During the whole 22-year period, basal area per acre increased from 104 to 127 square feet per acre (table 1). Previous experience on the Bartlett Experimental Forest indicates that 127 square feet is near the maximum that can be sustained in old-growth northern hardwood stands.

Table 1.--Periodic growth and development in trees 4.6 inches d.b.h. and larger

Year	Trees per acre	Basal area per acre	Accretion	Mortality	Ingrowth	Production[1]
	Number	Square feet	Square feet of basal area per acre per year			
1931-32	201	104				
			2.25	0.65	0.28	1.88
1939-40	206	119				
			1.75	1.41	.27	.61
1950-58	202	127				

[1]Production equals accretion minus mortality plus ingrowth; it is the average annual change in basal area during a growth period.

Annual production during the second growth period was about one-third of that during the first period--a result of decreased growth on the initial trees (decreased accretion) and higher mortality (table 1). The drop in accretion was probably due in part to the higher stand density that prevailed during the second growth period. A large share of the increased mortality during the second growth period was caused by the death of many large beech trees from the beech scale-Nectria complex, first discovered in this area in 1939.

Let's take a closer look at production--by size classes--as presented in table 2. In both growth periods,

Figure 1.--*An undisturbed old-growth northern hardwood stand on the Bartlett Experimental Forest. Beech, yellow birch, and sugar maple make up nearly three-fourths of the volume.*

higher production was associated with larger size class up through 16 to 20 inches. Production dropped again in the 21+ inch class as mortality took its toll.

Table 2.--Average annual production of trees 4.6 inches d.b.h. and larger, by growth periods and size classes

(Square feet of basal area per acre)

Year	D.b.h. size class, in inches				All
	5-10	11-15	16-20	21+	
1931-32	0.11	0.35	0.84	0.58	1.88
1939-40	-.20	.20	.59	.02	.61
1950-58					

The net effects of this parabolic trend in growth over the 22-year period were an increase of 9 percent in the proportion of basal area in trees of 16 to 20 inches, and a decrease in the 21+ inch class of 1 percent (table 3). This

Table 3.--Percentage distribution of basal area by size classes and year--trees 5.0 inches d.b.h. and larger

D. b.h. group (inches)	1931-32	1950-58
	Percent	Percent
5-10	38	31
11-15	34	33
16-20	18	27
21+	10	9

trend indicates that high-graded old-growth northern hardwoods--barring heavy losses from disease or windthrow--will gradually regain the characteristics of the virgin forest, which contained a high proportion of its growing stock in trees 16 inches and larger.

Species Behavior

Moderate changes in species composition occurred during the 22-year period (table 4).[2] Heavy mortality of large beech trees during the second growth period, coupled with a moderate rate of growth during the first period, was responsible for a 3-percent drop in the proportion of this species.

Low or negative production of yellow birch in all size classes was reflected by a 4-percent decline in its representation. Eastern hemlock made moderate to good growth in most size classes for both growth periods, followed by sugar maple. Hence the percentages of these species increased slightly. The proportion of red maple increased 5 percent because of its exceptionally good growth in all size classes up through the 16- to 20-inch class. Although paper birch also grew well in the smaller size classes, generally poor performance in the 16- to 20- and 21+ inch classes contributed to its slight decline.

Table 4.--Species composition in percent of basal area, by years

Year	Beech	Yellow birch	Sugar maple	Red maple	Paper birch	White ash	Red spruce	Eastern hemlock	Others[1]
1931-32	44	17	11	8	5	1	4	9	1
1939-40	43	16	11	9	5	2	3	10	1
1950-58	41	13	12	13	4	2	3	12	--

[1]Includes small proportions of aspen, pin cherry, striped maple, red oak, black ash, and balsam fir.

Drawing on past experience at the Bartlett Experimental Forest, coupled with close examination of the 50 cruise-plot records, we can generalize on species behavior is unmanaged northern hardwoods as follows: the growth pattern of a given species is largely a function of tolerance, longevity, and relative growth rate.

The tolerant and long-lived beech, sugar maple, and eastern hemlock show a fairly steady increase in production rate[3] with increased d.b.h. up through the 21-inch and larger d.b.h. size class.

---

[2]White ash, red spruce, and other miscellaneous species are excluded from the discussion because of insufficient data.

[3]Production rate equals annual production in basal area expressed as a percentage of the initial basal area in a size class.

Figure 2.--*A group of mature to overmature paper birch trees, ranging up to 16 inches d.b.h.*

The less tolerant and shorter-lived red maple and paper birch usually occur as essentially even-aged groups, occupying small openings within these uneven-aged old-growth forests. Depending upon the size of the opening and the severity of overhead and side competition, production rate in the 5- to 10-inch class varies from fair to good. With the increased light available to the dominant and codominant trees of 11 to 15 inches d.b.h., production rates of these fast-growing species greatly improve. Paper birch reaches maturity and begins to decline rapidly at or before 16 inches (fig. 2). The production rate of red maple appears to level off between 16 and 20 inches.

The slow growth[4] and intermediate tolerance of yellow birch are responsible for its unique performance in unmanaged old-growth stands. The saplings that become established in small openings are often quickly outstripped by faster-growing associates. Since the species cannot withstand suppression for long, mortality is high and production is low in the 5- to 10-inch size classes. Fairly good growth is sometimes exhibited by trees of 11 to 15 inches which have maintained a dominant or codominant position in the canopy. But, although yellow birch is fairly long-lived, production rates in larger size classes generally drop because of heavy mortality and decreased vigor.

Conclusion

This information on the development of an unmanaged northern hardwood stand and its component species gives some indication of the growth potential of these forests as well as the need and opportunities for skillful management. Depending upon the objectives of the owner, appropriate cutting methods may vary widely. But success under any system will depend to a large extent upon accurate evaluation and full consideration of the tolerance, longevity, and relative growth rates of each major species.

●

[4]There is ample evidence that yellow birch is one of the slowest growing, if not the slowest growing, component of northern hardwood forests. See Jensen, V. S., Suggestions for the management of northern hardwood stands in the Northeast, Jour. Forestry 41: 180-185, 1943; and Gilbert, A.M., et al., Growth behavior of northern hardwoods after a partial cutting, Jour. Forestry 53: 488-492, 1955.